LWG
LOWER WILLAMETTE GROUP

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February 12, 2015

Kristine Koch
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1200 Sixth Avenue, Suite 900, M/S ECL-115
Seattle, WA 98101-3140

Re: EPA Draft Portland Harbor Remedial Investigation Report Executive Summary (Lower Willamette River, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240)

Dear Kristine:

The Lower Willamette Group appreciates the opportunity to review EPA's draft Executive Summary for the final Portland Harbor Remedial Investigation Report. As mentioned to you last week, the LWG has significant concerns about EPA's draft Executive Summary, and because you were unavailable to meet with us during the 30 day review and discussion period allowed by the September 24, 2013 RI Process Agreement, these concerns remain unresolved. We are therefore providing our comments to you in writing and, consistent with the RI Process Agreement, simultaneously elevating them to EPA and LWG senior managers.

EPA has described Portland Harbor as "one of the largest Superfund sites in the nation, with contamination resulting from a long history of industrial activity and urban development, making for a very complex set of conditions in the Harbor."[1] The RI Report compiles, analyzes and synthesizes hundreds of thousands of data points collected over more than two decades. Together with the Feasibility Study, it must "provide the scientific foundation for the remedy at the site."[2] The Executive Summary must be more than a cursory abstract; it should provide a clear, technically accurate summary of key findings of the RI and a road map to specific information within the report for EPA managers and other decision makers.

EPA's January 13, 2015 draft Executive Summary condenses an approximately 600 page report into just over 9 pages, resulting in a document that is confusing and inaccurate. In some

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[1] McLerran letter to Pedersen, October 21, 2014.
[2] *Id. See also, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (Interim Final),* p. 1-3 (OSWER Directive 9355.3-01, October 1988) ("The objective of the RI/FS process is … to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site"); *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, p. 1-4 (OSWER Directive 9200.1-23P, July 1999) ("During an RI/FS, the lead agency gathers or oversees the gathering of information to support an informed decision regarding whichremedy (if any) is most appropriate for a given site or an operable unit within a site").

instances, context information necessary for a reader to understand the concept being discussed was omitted. In others, unrelated concepts were juxtaposed in a manner that unintentionally invites a reader to draw wrong conclusions. In places, scientific terminology has been replaced by imprecise language (sediment types are described in a range from "muddy sand" to "sandy mud" to "pure mud"). In others, the text is dense enough to deter readers who do not have a scientific background (metals "may be stored in calcium carbonate matrices or bone, which tend to reduce the reactivity of the metal"). Other text is just wrong ("hunting" is not a primary river recreation activity at Portland Harbor).

A couple of specific examples illustrate the confusion created by condensing so much scientific information into such a short summary.

Absence of critical context information: EPA's description of the key findings of the Baseline Human Health Risk Assessment notes that "the highest noncancer hazards are associated with nursing infants of mothers, who consume resident fish from Portland Harbor. When fish consumption is evaluated on a harbor-wide basis, the estimated RME HI is 4,000 and 10,000 for breastfed infants of recreational and subsistence fishers, respectively." The summary fails to explain that EPA's calculation of this risk assumes maternal consumption of 49 to 142 grams per day (6.5 to 19 eight-ounce fish meals per month) for at least 20 years prior to breastfeeding. This equates to the mother eating 1,500 to 4,500 meals of resident fish from Portland Harbor before giving birth. The context behind the conclusions of the risk assessments is critical information for risk managers and should be included in an executive summary of the document.

Confusion created through juxtaposition of discrete concepts: EPA condenses its description of sources of contamination within Portland Harbor into just a single paragraph:

> Historical sources have released contaminants to the river in the past, but no longer have an upland source to control. Historical releases likely contributed to the majority of the observed chemical distribution in sediments within the Study Area. Many of the historical direct discharges were combined flows of stormwater, industrial wastewater, and sanitary wastewater. Additionally, waste disposal in upland pits, lagoons, or lakes were directly discharged to the river through pipes, ditches, and creeks. Releases were known to have occurred through DEQ investigations at 86 upland sites, generally located within 0.5 mile of the lower Willamette River between RM 2 and 11. Some of the most significant current sources are the result of historic commercial operations, waste disposal, spills and leaks that contaminated soil, groundwater, or the banks that continue to be released to the Site. Contaminants released from sources to media such as air, soil, ground water, surface water, or impervious surfaces may migrate to the lower Willamette River via direct discharge through conveyance systems, overland transport, groundwater flow, riverbank erosion or leaching, atmospheric deposition, overwater activities, and via transport from the upstream watershed.

As written, this paragraph suggests that all DEQ investigations have evaluated "historical sources" that "no longer have an upland source to control." The text further suggests that "significant current sources" are apparently both uncontrolled and uninvestigated. In fact, DEQ is actively investigating sites with both historical and current sources, and DEQ source control is in progress at many, but certainly not all, of the 86 upland sites. Source control is a key technical consideration for remedy selection, and the source control information provided by EPA's Executive Summary is, at best, extremely confusing.

A table compiling a more detailed list of missing or incorrect information in EPA's Executive Summary is enclosed as Tab 1 to this letter, but this list is also far from exhaustive. We did not attempt to create an exhaustive list of our concerns with the Executive Summary; as described below, we believe it is more helpful to provide EPA with a recommended alternative version.

Because the executive summary may be the only section of a long, highly technical report reviewed by some readers, "it must accurately and concisely reflect the original document. It should restate the document's purpose, scope, methods, findings conclusions and recommendations as well as explain how results were obtained or the reasons for the recommendations."[3] An executive summary should present scientific and technical concepts using terms appropriate for the intended readers of the document.[4] The executive summary should be about 10 percent of the length of the original document and should generally follow the same sequence.[5]

As discussed above, the RI/FS provides "the scientific foundation for the remedy at the site." Therefore, the purpose of the Executive Summary should be to summarize the contents of the RI report for EPA managers and other decision-makers. Although the LWG shares EPA's objective to appropriately communicate the results of the information collected during the RI to the public, the RI Report itself is a highly technical document, and the Executive Summary must present the information in the RI Report in sufficient detail to accurately explain the methods and conclusions of the 14 year, $100 million investigation of the "very complex set of conditions" at Portland Harbor. "When an agency prepares a specialized or technical publication, the agency should take into account the subject expertise of the intended audience."[6] Other vehicles – such as fact sheets and presentations – are better suited to providing brief, less technical summaries of information about the RI to the public.

Because your schedule has not allowed us to meet with you to discuss our understanding of the objectives for and necessary content of the Executive Summary to the RI Report, we concluded that the most efficient method of communicating our views to EPA would be to prepare a recommended alternative Executive Summary. The LWG's recommended Executive Summary, enclosed at Tab 2, draws upon information highlighted in EPA's January 13 draft, the Executive Summary prepared by the LWG for the 2011 draft final RI Report based on prior EPA comments, and recent summaries of information jointly prepared by EPA and the LWG for the RI Conceptual Site Model. At 20 pages, the LWG's recommended Executive Summary is about 3 percent of the length

[3] Alred, Brusaw and Oliu, *Handbook of Technical Writing*, p. 182 (8th Ed. 2006)
[4] *Id.*
[5] *Id.*
[6] *Final Guidance on Implementing the Plain Writing Act of 2010*, p. 5 (OMB, April 13, 2011).

of the original document, shorter than executive summaries typically included in similar reports (e.g., the Lower Duwamish at 33 pages). The LWG believes that this summary contains the bare minimum of information that should be readily available to EPA managers and others relying upon the RI Report to make risk management decisions for Portland Harbor.

Please let us know if you would like to discuss these comments.

Sincerely,

Bob Wyatt

cc:

Sean Sheldrake, U.S. Environmental Protection Agency, Region 10
Confederated Tribes and Bands of the Yakama Nation
Confederated Tribes of the Grand Ronde Community of Oregon
Confederated Tribes of Siletz Indians of Oregon
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of the Warm Springs Reservation of Oregon
Nez Perce Tribe
Oregon Department of Fish & Wildlife
United States Fish & Wildlife
Oregon Department of Environmental Quality
LWG Legal
LWG Repository

TAB 1

List of Some Technical Errors and Confusing Statements EPA's Draft RI Executive Summary

List of Some Technical Errors and Confusing Statements
EPA's Draft RI Executive Summary

EPA Text	Location	LWG Concern
"This RI report evaluates the environmental data collected and compiled since the inception of the Portland Harbor Remedial Investigation and Feasibility Study (RI/FS) in 2001."	Page 1, paragraph 1	The RI does not include all the environmental data collected since 2001 (e.g., EPA's 2012 fish sampling data; some in-water investigations by various parties...).
"The long history of industrial and shipping activities in Portland Harbor, as well as agricultural, industrial, and municipal activities upstream of Portland Harbor, have contributed to chemical contamination of surface water and sediments."	Page 1, paragraph 3	Historical agricultural, and municipal activities in the harbor have also contributed contaminants.
"The lower Willamette River and Portland Basin as a whole provide resources of cultural significance to Native peoples."	Page 2, paragraph 1	"Portland Basin" in never defined and therefore the use of this phrase is confusing.
"Near shore areas between the channel edge and riverbank, and off-channel areas, such as Swan Island Lagoon, Willamette Cove, and port terminals, do not show much net sediment accumulation."	Page 2, last paragraph	Many of these areas do show net accumulation (e.g., the eastern nearshore reach from RM 2 to 3), which is why they require periodic maintenance dredging.
"Preferential pathways focus groundwater flow, particularly where they occur in predominantly fine-grained sediment sequences in the shallow groundwater system. The majority of discharge to the river generally occurs where these preferential pathways intersect the riverbank."	Page 3, paragraph 1	The majority of groundwater discharge to the river is not at these finite preferential pathway locations, but via general diffused intrusion throughout the riverbed.
"The depth and degree of mixing is anticipated to be relatively small in shallow river sediments, and groundwater likely comprises a greater percentage of the water in the shallower water bioactive zone."	Page 3, paragraph 2	Unclear what "shallow" and "shallower" refer to in this sentence
"Active dredging has produced a uniform channel with little habitat diversity."	Page 3, paragraph 4	The main channel of the lower Willamette River never had much habitat diversity, so it is not correct to state active dredging produced limited habitat diversity.
"Critical habitat has been designated for four species of salmon and steelhead and proposed for one species by National Marine Fisheries Service (NFMS) in the lower Willamette River."	Page 3, paragraph 4	This sentence seems out of place in the Riverbanks section; it seems better suited to habitat discussion under Surface Water.
"The most common bank types occurring in the Study Area are riprap, sandy and rocky beach, unclassified fill, and seawall."	Page 3, paragraph 4	There is not much seawall in the Study Area, so it is incorrect to include seawalls as part of the "most common bank types…"

List of Some Technical Errors and Confusing Statements
EPA's Draft RI Executive Summary

EPA Text	Location	LWG Concern
"Historical sources have released contaminants to the river in the past, but no longer have an upland source to control."	Page 4, paragraph 1	This sentence contradicts the next sentence we copied from further down in paragraph 1 (next row on this table).
"Some of the most significant current sources are the result of historic commercial operations, waste disposal, spills and leaks that contaminated soil, groundwater, or the banks that continue to be released to the Site."	Page 4, paragraph 1	See comment above.
Bulleted list of areas with co-located contaminants	Page 5, top	List is incomplete. There are two more bullets of locations downstream of RM 5 that are not included here that are listed in the analogous list from RI Section 10.1.
"Historical contaminant loading is reasonably expected to have occurred by all of the loading mechanisms discussed above and the historical load may be significantly greater than current load due to changes in regulations and reduction or elimination of chemical use in the Study Area and Willamette Basin."	Page 5, last paragraph	Again, this is a confusing sentence attempting to summarize various complex processes and concepts. Expanded text is warranted.
"The primary current mechanisms for riverbank erosion are river water moving over bank materials; direct overland transport across these materials; and erosion of bank material into the river."	Page 5, last paragraph	This sentence is extremely confusing and needs a complete re-write. For example, is "overland transport" related to vehicle traffic causing erosion, or surface water run-off causing erosion? Also, what is the difference between "river water moving over bank materials" and "erosion of bank material into the river"?
"The particulate fraction represents the larger component for PCBs, PCDD/Fs, DDx, pesticides, and metals."	Page 6, paragraph 1	This sentence needs to be rewritten. The particulate fraction represents the higher concentrations of contaminants, not the larger component of contaminants.
"In general, the ratios of particulate to dissolved mass loading for all surface water loading contaminants do not show large or consistent variations under different flow conditions, indicating possible conditions of equilibrium or near equilibrium."	Page 6, paragraph 1	This sentence is far too confusing and again attempts to summarize various complex concepts into one sentence. Expanded explanation is warranted for the reader to understand the issues. Also, it is unclear what equilibrium means in this context.

List of Some Technical Errors and Confusing Statements
EPA's Draft RI Executive Summary

EPA Text	Location	LWG Concern
"Fate and transport processes in sediment and TZW include distribution between the solid and aqueous phases, degradation and transformation processes (hydrolysis, dehalogenation, biodegradation, oxidation, and reduction, and physical transport processes resulting from natural and anthropogenic forces."	Page 6, paragraph 3	Fragmented sentence, and again attempts to summarize three extremely complex elements in one sentence. Further explanation for the reader is warranted.
"Current or potentially exposed populations were identified based on consideration of both current and potential future uses of the Study Area. Currently or potentially exposed populations were identified based on consideration of both current and potential future uses of the Study Area, and include…"	Page 7, paragraph 4	There are numerous typographical errors in this draft Executive Summary. We present this one as an example of a repeated sentence.
"Exposure point concentrations (EPCs) were calculated to represent the average concentration contacted over the duration of the exposure."	Page 8, first paragraph below bullets	This statement is not accurate. The BHHRA used either the maximum or 95% UCL concentrations for EPCs, which do not represent the average concentration, especially over the duration of the exposure.
Human Health and Ecological Risk Assessment Summaries.	Pages 7 though 10	The risk assessment summaries only discuss results that exceed acceptable risk ranges/criteria. The Executive Summary should also summarize the Reasonable Maximum Exposure scenarios that were evaluated and determined to be within EPA's acceptable risk ranges.
"The corresponding HI estimates for nursing infants of mothers, who consume fish, are 8,000 and 9,000 respectively, assuming maternal consumption of fillet or whole-body fish."	Page 9, paragraph 1	Misleading sentence (implies all mothers eat fish from Portland Harbor). Also, it is misleading to the public to simply convey the high HIs without context (e.g., the mother eats 6.5 to 19 meals per month of resident fish from Portland Harbor for 20 years before initiating breastfeeding).

TAB 2

LWG Recommended Executive Summary

Executive Summary

In December 2000, the U.S. Environmental Protection Agency (EPA) identified the Portland Harbor area of the lower Willamette River (just north of downtown Portland, Oregon) as a priority for cleanup and placed it on the National Priorities List as a Superfund site.

The remedial investigation (RI) report presents the compilation and evaluation of site investigation work conducted by the LWG and others from 2001 through July 2010 to characterize the Portland Harbor Superfund site (the Site), to assess risks to human health and the environment, and to lay the groundwork for a feasibility study (FS) to evaluate cleanup options.

The Superfund work in the Portland Harbor area is one of many efforts focused on the greater Willamette River watershed. Other initiatives that address water quality, public health advisories, and land use are being conducted under several other federal and state programs, such as the Clean Water Act.

Overview of the Remedial Investigation

The RI was conducted by the Lower Willamette Group (LWG), 10 parties who signed an Administrative Settlement Agreement and Order on Consent (AOC) with EPA to conduct the RI and FS at the Site and 4 other parties who have contributed financially to the project. The LWG is a small subset of potentially responsible parties identified by EPA.

From 2001 to 2008, the LWG conducted the sampling and analysis described in Section 2 of the RI report under the oversight of EPA and its partners, including the Oregon Department of Environmental Quality (DEQ) and the Site's Natural Resource Trustees (U.S. Department of the Interior, National Oceanic and Atmospheric Administration, State of Oregon, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Grand Ronde Community of Oregon, Confederated Tribes of the Siletz Indians of Oregon, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe). EPA is the lead agency for investigating and selecting a remedy for the in-river portion of the Site. DEQ is the lead agency for investigating and controlling sources of contaminants from the upland portions of the Site.

The RI report describes the nature and extent of contamination (Section 5), characterizes sources of contaminants (Section 4) and the physical conditions that affect their movement and fate (Sections 3 and 6), and assesses risks those contaminants may pose to human health (Section 8) and the environment (Section 9). Upstream or background sediment quality data needed to support the development of cleanup goals in the FS were also evaluated in the RI report (Section 7). Finally, a conceptual site model (CSM) was developed to synthesize information gathered during the RI, including contaminant sources and release mechanisms, pathways to the river, in-water transport and fate processes that affect the mobility of contaminants, and exposure and risks to ecological and human receptors (Section 10).

Study Area

The Initial Study Area (river mile [RM] 3.5 to RM 9.2), as defined by EPA in the AOC, was based on the results of the 1997 Site Investigation. The Initial Study Area was expanded upstream and downstream over the course of the RI as additional site characterization data and upland source information were compiled and evaluated. The final Study Area for the RI is a 10-mile stretch of the lower Willamette River (Figure ES-1). It is located north of downtown Portland between Sauvie Island at RM 1.9 and the Broadway Bridge at RM 11.8. The RI also includes data and source information from areas downstream and upstream of the final RI Study Area, including immediately upstream in the downtown Portland reach (RM 11.9 to 15.3), and an upriver or background reach from RM 15.3 to 28.4. This information will support EPA's determination of the final site boundary to be documented in the Record of Decision.

The Willamette River is the 13th largest river in the contiguous United States in terms of discharge, with substantial flows, averaging 33,000 cubic feet per second. Flows vary considerably by season, with the lowest flows occurring during the late-summer dry season, and typically increasing by 10 times through the winter rainy season. River flows in the lower Willamette are regulated to some degree by a series of upstream dams, although high-flow events of 200,000 cubic feet per second or more still occur every few years during large storms. Despite periodic scouring of some locations, the Study Area is situated in a relatively low energy, depositional reach of the river. The lower Willamette River is more than 100 miles from the Pacific Ocean, yet influenced by tides. Tides cause the river stage to rise and fall up to several feet through a tidal cycle. During the dry season, when river discharge is low, rising tides can cause intermittent flow reversals throughout the harbor.

The Study Area is an urban and industrial reach of the lower Willamette River. What was once, more than 100 years ago, a shallow, meandering portion of the Willamette River has been redirected, and channelized via filling and dredging. A federally maintained navigation channel, extending nearly bank-to-bank in some areas, doubles the natural depth of the river and allows transit of large ships into the active harbor. Much of the riverbank contains overwater piers and berths, port terminals and slips, and other engineered features (e.g., armoring such as rip rap makes up approximately half of the harbor shoreline). These extensive physical alterations have resulted in a river reach that bears little resemblance to its pre-industrialized character in terms of hydrodynamics, sediment processes, ecological habitat, and human uses.

Section 3 of the RI report details the biological and human uses of Portland Harbor. The Study Area is an active working harbor and also supports invertebrate, fish, and wildlife communities as well as human recreation (e.g., boating, fishing, beach uses). Ecological and human uses of the Study Area are briefly summarized below.

Ecosystem

Portland Harbor includes habitat for invertebrates, fishes, birds, mammals, amphibians, reptiles, and aquatic plants. Each group makes a contribution to the ecological function of the river, with its relative importance depending on its niche, its abundance, and its interaction with the physical environment.

The invertebrate community living in the sediments of Portland Harbor is dominated by worms, midge (fly) larvae, amphipods (small shrimp-like animals), mayfly larvae, caddisfly larvae, flatworms, crayfish, and the invasive Asiatic clam. Many of these benthic invertebrates provide important food for fish in the Study Area.

The diverse fish species that use Portland Harbor include migratory fish, such as salmon, lamprey, and sturgeon, and numerous resident fish, including recreational species such as smallmouth bass. Fish in the harbor provide an important food resource for birds, such as osprey and bald eagle, and some larger fish species like northern pikeminnow and smallmouth bass. Many aquatic mammals also feed on fish.

Birds that use the harbor include many migratory and resident species. Resident birds such as bald eagle, Canada goose, mallard, spotted sandpiper, great blue heron, and others are found in the Study Area. Spotted sandpiper, osprey, and bald eagle were selected for evaluating ecological risk to birds, the sandpiper because of its habit of probing mud for food, and osprey and bald eagle because they prey on fish and are high on the food chain.

Mink and river otter were used for assessing ecological risks to mammals because they feed on fish and shellfish. Mink are rare in the Study Area due to limited habitat. Evidence and sightings of river otter are more common. Other mammals with habitat in the Study Area include beaver, muskrat, raccoon, and California sea lion.

Portland Harbor provides limited habitat for amphibians and reptiles. Most of the native amphibians that might be found in Portland Harbor prefer undisturbed areas that offer seasonal wetlands with emergent plants and shallow waters. Most local reptile species prefer wet vegetated upland habitats.

Aquatic plant communities are used by wildlife for refuge and for nesting and breeding habitat. The plants also provide food for herbivores and play a role in the cycling of nutrients. Habitat constraints in Portland Harbor, including muddy water and overwater obstructions (e.g., docks) that prevent the sun from reaching the bottom plus extensive bank armoring, limit the development of dense submerged and emergent plant communities in the Study Area.

Human Use

Industrial and urban development of Portland Harbor and adjacent areas has been extensive. The majority of the shoreline in the Study Area is currently zoned for industrial land use and is designated by the City of Portland as an "Industrial Sanctuary," with associated industrial and commercial worker activities. Section 3 of the report details the history of industrial, commercial, and infrastructure (e.g., conveyance systems) development in the Study Area. Current uses of the land and water in Portland Harbor include:

- Industrial and commercial operations
- Marine activities
- Surface transportation (railroads and roadways)

Portland Harbor also provides recreational opportunities both on the river and along the riverbanks. Additionally, there are residential areas located near the river and upstream and downstream of the Study Area. Recreational activities are associated with the public access areas, such as beaches and boat ramps, and may include water skiing, occasional swimming, and waterfront recreation. Fishing for salmon, sturgeon, and other species is conducted throughout the Study Area, both by boaters and from locations along the banks. The lower Willamette River also provides Native American ceremonial and subsistence fisheries for Pacific lamprey (particularly at Willamette Falls) and spring Chinook salmon. In addition, transients have been observed along the lower Willamette, including some locations within the Study Area.

DATA COLLECTED FOR THE REMEDIAL INVESTIGATION

The field investigations to support the site characterization were performed by the LWG between 2001 and 2008. Three major rounds of environmental sampling addressed different site characterization needs, often timed around varying river stages, seasonal river flows, and storm events. Extensive physical studies (e.g., time-series bathymetric surveys) and sampling and chemical testing of sediment, surface water, transition zone water (TZW), and biota were conducted to support the RI, the risk assessments, and the FS. Environmental sampling and data collection for the RI is described in Section 2 of the report.

Round 1 sampling, which focused on the collection of biota (tissue) samples, was conducted in 2002. Round 2 sampling began with multiple field efforts in 2004 and focused on the characterization of surface and subsurface sediment quality. In 2006, specialized sampling to support the hydrodynamic sediment transport model (e.g., surface sediment erosion rates) was conducted. Round 3 sampling between 2006 and early 2008 included collecting samples of surface water, biota, sediment upstream and downstream of the Study Area, suspended sediments (in-river sediment traps), and stormwater from selected outfalls. Round 3 sampling also filled data gaps related to site characterization, ecological and human health risks, upriver background, and the FS. A summary of the types and numbers of samples collected and/or compiled for the RI is tabulated below.

Data Collected/Compiled for the Portland Harbor Remedial Investigation

Number of Samples/Surveys	Collected Sample Types and Investigations	Number of Locations Sampled	Number of Analytes Measured per Media
2,471	Surface sediment and beach composite samples	2,423	684
3,184	Subsurface samples	1,113	607
480	Composite tissue samples	254	447
297	Surface sediment samples tested for toxicity to aquatic invertebrates	293	441
3,159	Surface water samples from fixed point and transect stations	107	500
420	Transition zone water samples	152	229
73	In-river sediment trap samples	28	519
412	Stormwater outfall composite water samples	114	510
6	Groundwater seep samples	3	111
523	Sediment profile images	478	14
836	Sediment trend analysis sample points	836	1
5	Major bathymetry surveys of 16 miles of the lower Willamette River		
3	Acoustic Doppler Current Profiler surveys		
1	Hydrodynamic and sediment transport model data collection effort		
In addition, the LWG conducted three wildlife habitat surveys and a cultural resource survey.			

Note: Table includes data collected by LWG and other relevant studies

The sediment, water, and tissue samples tabulated above were analyzed for an extensive list of environmental contaminants, including metals, tributyltin ion (TBT), polychlorinated biphenyls (PCBs), dioxins, DDT and other pesticides, semivolatile and volatile organic compounds (SVOCs, VOCs), phenols, herbicides, and polybrominated diphenyl ethers (PBDEs).

REMEDIAL INVESTIGATION RESULTS

Physical System

The Study Area is located within Portland Harbor, which occupies the lower 12 miles of the Willamette River above its confluence with the Columbia River. It is the widest portion of the lower Willamette River and, overall, acts as a depositional environment for sediments that enter the reach from upstream; approximately 20 percent of the suspended sediments entering the harbor from upstream are deposited in the Study Area (Section 6). Consequently, sediments need to be periodically dredged from portions of the navigation channel and berthing areas to allow safe navigation of commercial vessels. Sediments in some locations may be resuspended and transported downstream during periods of high flow and from anthropogenic disturbances, such as vessel operations in the harbor. The degree of deposition and movement of sediments is controlled largely by river hydrodynamics and the sediment texture (i.e., grain size and organic matter content). Suspended fine-grained sediments (silts and clays) are typically transported farther than larger sandy sediments under all flow conditions.

Bathymetric changes from 2002 to 2009 show the greatest net sediment accumulation occurs where the channel is wide and where flow velocities are reduced (Figure ES-2). These shoals are predominantly fine-grained sediments. Long-term deposition rates exceeding 1 ft (30 cm) per year are evident in some sections of the channel, for example, in the large shoal present in the western half of the river from RM 7 to 10. Some areas of natural scour and dredging are also evident in the bathymetric change data. In the scour areas, such as in the channel from RM 5 to 7, sediments are predominately sand and appear to be relatively stable during low-flow conditions but are mobilized when flow velocities are high.

Nearshore and off-channel areas, such as Swan Island Lagoon, Willamette Cove, and port terminals, generally show less sediment accumulation than the depositional channel areas, but most nearshore areas appear to be physically stable and many accumulate sediments over time (as evidenced by the need for periodic maintenance dredging). Sediment scour in some nearshore locations appears to be due to ship traffic (wakes and prop wash) and other human activities. These disturbance factors also appear to mix surface sediments in the absence of net erosion or deposition.

The physical system of the Study Area is described in Section 3 of the report.

Sources of Contamination

Historical releases of contaminants contributed to the majority of the observed chemical distribution in sediments within the Study Area. Contaminants from upland areas have entered the river system as direct discharges through stormwater and wastewater outfalls, from overwater releases and spills, and indirectly through overland flow, bank erosion, groundwater, and other nonpoint sources. In addition, contaminants from regional sources have reached the Study Area through inputs of surface water and sediment from upstream and through atmospheric deposition. Historical and current sources responsible for the existing contamination include, but are not limited to 1) ship building, repair, and dismantling; 2) wood treatment and lumber milling; 3) storage of bulk fuels and manufactured gas production; 4) chemical manufacturing and storage; 5) municipal combined sewer overflows; and 6) stormwater from industrial, commercial, transportation, residential, and agricultural land uses. Contaminants have been released to the river over many decades, including metals, PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs) from petroleum and other sources, and phthalates. Recent source control activities, including termination of some historical operations and improved waste management practices, have significantly reduced the amount of contaminants being released to the Study Area.

Some of the current sources of contaminants to the Study Area are soil, groundwater, and river banks that contain (e.g., from historical spills, leaks, and waste disposal) and continue to release legacy contaminants. Contaminants may also reach the river via direct discharge through conveyance systems, atmospheric deposition, and overwater activities.

Agricultural runoff and discharges from other industries and cities upstream as well as point and nonpoint discharges within the broader Willamette River Basin are potential historical and current sources of contamination in sediment, surface water, and biota in the Study Area. Both point sources and nonpoint sources of contamination are present above Willamette Falls in the upper Willamette River. Agriculture, forestry, urban land use, geologic features, and atmospheric deposition may have contributed to conditions in Portland Harbor.

Sources of contamination are described in Section 4 of the report.

Distribution of Contaminants

Because of the large number of contaminants detected in various media both upstream and within the Study Area, a subset of contaminants was selected as indicator contaminants in the RI report to facilitate the presentation of the distribution of contaminants identified in the Study Area. The indicator contaminants are:

- Total PCBs
- Total polychlorinated dibenzo-*p*-dioxin/furans (PCDD/Fs)
- Total DDx (sum of 2,4- and 4,4- dichlorodiphenyltrichloroethane [DDT], dichlorodiphenyldichloroethane [DDD] and dichlorodiphenyldichloroethene [DDE])
- Total PAHs
- Bis(2-ethylhexyl)phthalate (BEHP)

- Total chlordanes
- Aldrin
- Dieldrin
- Arsenic
- Chromium
- Copper
- Zinc
- TBT.

Section 5 of the RI report contains a detailed evaluation of the indicator contaminants in the Study Area. Maps and summary data tables for another 21 contaminants are presented in Appendix D. The entire site database for all contaminants and media is provided in Appendix A3.

All contaminants potentially posing unacceptable risk are evaluated in the Portland Harbor RI/FS. To illustrate the broad patterns of sediment contamination found in the Study Area, the overall concentrations and spatial distribution of four contaminant groups (total PCBs, total PCDD/Fs, total DDx, and total PAHs) are noted below.

Summary Statistics for Total PCBs, Total Dioxins/Furans, Total DDx, and Total PAHs in Surface and Subsurface Sediment, Study Area (RM 1.9-11.8)

Analyte	Number Analyzed	Concentration			
		Mean	Median	95th Percentile	Maximum
Total PCBs (µg/kg) ppb					
Surface Sediment	1,318	220	27	736	35,400
Subsurface Sediment	1,543	351	70	1,000	150,000
Total Dioxins/Furans (pg/g) pptr					
Surface Sediment	237	2,407	412	5,580	264,000
Subsurface Sediment	327	9,052	290	28,240	425,000
Total DDx (µg/kg) ppb					
Surface Sediment	1,249	268	7.5	460	84,909
Subsurface Sediment	1,659	11,367	15.4	4,938	3,643,000
Total PAHs (µg/kg) ppb					
Surface Sediment	1,661	27,167	1,180	66,630	7,260,000
Subsurface Sediment	1,696	248,670	1,390	288,550	53,300,000

Notes:
ppb = parts per billion pptr = parts per trillion

Bottom Sediments

The highest concentrations of contaminants in Study Area sediments were found in nearshore and off-channel areas (e.g., slips, embayments, and shallow areas) and near some known or suspected sources. Concentrations of organic contaminants and metals tended to be higher in subsurface sediments than in surface sediments, particularly in depositional areas. The navigation channel, Multnomah Channel, and areas downstream and upstream of the Study Area had lower contaminant concentrations in sediment, especially for organic contaminants.

Well-defined areas of elevated concentrations of PCBs in sediments were identified at specific locations within the Study Area, mostly associated with known likely sources (Figure ES-3). PCBs concentrations were generally higher in subsurface sediments, indicating impacts from historical sources. Elevated concentrations of total PCDD/Fs were mostly concentrated in nearshore sediments at the center of the Study Area around RM 7. The area of highest total DDx concentrations occurred along the western shoreline near known historical sources between RM 6 and 7.5. Total DDx concentrations were higher in the subsurface than in the surface layer, indicating predominantly historical point and nonpoint sources of DDx. With few exceptions, total PAHs concentrations were higher in subsurface than in surface sediments. Total PAHs concentrations were highly variable across the Study Area, with peak concentrations around RM 6, near known likely sources (Figure ES-3).

Upstream areas characterized during the RI for comparison with the Study Area included the downtown reach (RM 11.9 to 15.3), which is immediately above the Study Area, and a reach from upriver of Ross Island to Willamette Falls (RM 15.3 to 28.4). The Willamette River is narrow in these upstream areas, resulting in higher flow velocities and sandier sediments. Excluding some known or suspected source areas and cleanup sites in the downtown reach, sediment contaminant concentrations in the upstream areas are generally lower than in the Study Area.[1]

[1] Contaminant concentrations in Portland Harbor may be due to releases from the Site itself, as well as natural and/or anthropogenic sources that are not Site-related. An understanding of background conditions is important at Portland Harbor because of the urbanized and industrialized setting, and the fact that the lower portion of the river is influenced by many human activities occurring upstream and throughout the watershed. Thus, Site-specific background concentrations can be used to develop remedial goals and characterize risks that are attributable to background contaminant levels. The upriver reach of the lower Willamette River extending from RM 15.3 to 28.4 was selected as the reference area for determining background sediment concentrations. The area is representative of the urban and suburban upland conditions along the banks of the lower Willamette River as it flows into Portland through its suburbs, but is upstream and uninfluenced by releases from the Portland Harbor Study Area. For the RI, background concentrations were calculated for arsenic, total chlordanes, chromium, copper, total DDx, BEHP, mercury, total PAHs, PCBs as Aroclors, PCBs as congeners, total PCDD/Fs, and zinc. Background concentrations were not established for aldrin, dieldrin, and TBT due to their infrequent detection in the upstream reach data set. The background evaluation is described in Section 7 of the report.

Locations exhibiting higher elevated contaminant concentrations in the Study Area appear to be physically stable over time. However, migration of some contaminants is evident in limited areas consistent with source types and general sediment transport patterns. Sediments immediately downstream of the Study Area in the Willamette River and Multnomah Channel showed little evidence of contaminant migration from the Study Area.

Suspended Sediments

Elevated concentrations of contaminants in sediment trap samples correspond with areas with high concentrations in surface sediments, indicating the effect of erosion and resuspension of bottom sediment, the presence of current sources, or both. Sediment trap samples from the Study Area had higher concentrations of indicator contaminants than samples from upstream of the Study Area.

Surface Water

Concentrations of PCBs, pesticides, PCDD/Fs, and PAHs in surface water were measured down to extremely low levels, parts per quadrillion in some cases, using specialized sampling techniques. Concentrations of these contaminants in surface water samples varied both spatially and with river flow.

Concentrations of total PCBs, total PCDD/Fs, and total PAHs in surface water within the Study Area were higher than those upstream of the Study Area under all flow conditions. Elevated concentrations were observed in both transect (i.e., cross-river composite samples) and single-point surface water samples at various locations throughout the Study Area. The highest concentrations of total DDx and total PAHs in surface water during low-flow conditions were found adjacent to known sources of these contaminants. The highest total PCB concentrations were associated with single-point samples collected at RM 6.7 within Willamette Cove during low-flow conditions. At RM 2, at the downstream end of the Study Area, concentrations of total PCBs, total PCDD/Fs, total DDx, and total PAHs in surface water were generally lower than in the rest of the Study Area.

Concentrations of total PCBs and total PAHs in surface water tended to decrease with increasing flow rates due to the effect of dilution under higher flow conditions. No clear relationship was found between total dioxins/furans concentrations and river flow. Total DDx concentrations in surface water upstream of the Study Area were elevated in high-flow conditions, suggesting some DDx was mobilized from upstream sources during high-flow conditions.

Transition Zone Water

As part of the groundwater pathway assessment investigation conducted for the RI, samples of TZW (pore water) in surface and near-surface sediments were collected offshore of nine upland sites in the Study Area where groundwater was suspected of potentially impacting sediment and/or pore water quality. The groundwater pathway was shown to potentially influence surface sediment/pore water quality at four of these nine sites.

Fish and Invertebrate Tissue

PCBs, PCDD/Fs, DDx, and PAHs were detected in most samples of the various fish and invertebrate species collected across the Study Area. Concentrations of these and other contaminants varied greatly within and between species, with fish tissue concentrations generally greater than those in invertebrates. Concentrations of bioaccumulative compounds such as PCBs and DDx were often found at greater concentrations in organisms higher on the food chain. On a site-wide scale, biological samples from within the Study Area exhibited greater concentrations of most indicator contaminants than those seen in samples from upriver reaches and above Willamette Falls. Localized areas of elevated concentrations of some indicator contaminants were found in resident species (e.g., sculpin), reflecting high concentrations in nearby surface sediment and biological uptake by species with small home ranges.

BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment (BHHRA) evaluated the potential for adverse human health effects from exposure to contaminants within the Study Area. The general objective of the BHHRA was to assess the potential risks to human health from exposure to contaminants present in sediment, surface water, and groundwater seeps, or accumulating in fish and shellfish. The results of the BHHRA will be used to refine remedial action objectives and to inform decisions about cleanup of the Site. The BHHRA is summarized in Section 8 of the report and found at Appendix F.

Approach to the Baseline Human Health Risk Assessment

The BHHRA evaluated the following exposure scenarios and receptors:

- **Dockside worker**—Direct exposure to (i.e., ingestion of and dermal contact with) beach sediment
- **In-water worker**—Direct exposure to in-water sediment
- **Transient**—Direct exposure to beach sediment, surface water, and groundwater seeps
- **Adult and child recreational beach user**—Direct exposure to beach sediment and surface water
- **Tribal fisher**—Direct exposure to beach sediment or in-water sediment, and fish consumption
- **Fisher**—Direct exposure to beach sediment or in-water sediment, fish consumption, and shellfish consumption
- **Diver**—Direct exposure to in-water sediment and surface water

- **Domestic water user—**Direct use of untreated river water as a drinking water source in the future
- **Infants**—Consumption of human breast milk.

The BHHRA incorporated conservative (i.e., health protective) assumptions in the development of exposure scenarios, the estimates of exposure, and the use of toxicity values, based on discussions with and direction from the EPA and its partners. The use of conservative exposure scenarios and toxicity values may overestimate risks, and this uncertainty is considered when making decisions about Site cleanup.

Results of the Baseline Human Health Risk Assessment

The major findings of the BHHRA[2] are:

- The BHHRA determined contaminants generally do not pose unacceptable excess cancer risk or non-cancer hazard for direct exposure to beach sediment, in-water sediment, groundwater seeps, and surface water.

- The human health risk assessment found that 27 contaminants (as individual chemicals, intermediate sums, or totals) posed potentially unacceptable risk to human health across all potential exposure routes (e.g., direct contact with sediments/water and fish/shellfish consumption), including metals, PAHs, PCBs, PCDD/Fs, DDT and other pesticides, PBDEs, a single phthalate, SVOCs, phenol, and herbicide compounds.

- Estimated risks from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment and surface water. Excess cancer risks from fish and shellfish consumption exceed the EPA point of departure (1×10^{-4}). Consumption of resident fish species (e.g., carp and smallmouth bass) consistently results in the greatest risk estimates. Evaluated harbor-wide, the estimated reasonable maximum exposure (RME) cancer risks are 4×10^{-3} and 1×10^{-2} for recreational and subsistence fishers, respectively.

- Noncancer hazard estimates for consumption of resident fish species are greater than 1 (EPA's point of departure) at all river miles. Based on a harbor-wide evaluation of noncancer risk, the estimated RME hazard index (HI) is 300 and 1,000 for recreational and subsistence fisher, respectively. The highest hazard

[2] The BHHRA findings described in the RI report are based on the RI data set, which includes data compiled through July 2010 and evaluated in the BHHRA. Additional sediment and tissue data have been incorporated into the FS data set and may be used to revise human health risk estimates and to inform the evaluation of remedy effectiveness.

estimates for recreational fishers are at RM 4, RM 7, RM 11, and in Swan Island Lagoon.

Evaluated on a harbor-wide scale, the estimated RME HI for tribal consumers of migratory and resident fish is 600 assuming fillet-only consumption, and 800 assuming whole-body consumption.

Potential noncancer hazards are associated with nursing infants whose mothers consume resident fish from Portland Harbor for 20 years prior to giving birth.

- PCBs are the primary contributor to risk from fish consumption harbor-wide. When evaluated on a river-mile scale, PCDD/Fs are a secondary contributor to the overall risk and hazard estimates.
- The impact of uncertainties associated with risk estimates for the fish and shellfish consumption scenarios will be taken into account for decisions about cleanup of the Site.[3] Risk estimates in the BHHRA are based on multiple assumptions that may underestimate or overestimate the actual risks.

ECOLOGICAL RISK ASSESSMENT

The baseline ecological risk assessment (BERA) evaluated the potential for adverse effects on plants, invertebrates, amphibians, fish, and wildlife from contaminants within the Study Area. The primary objective of the BERA was to characterize the risks of chemical effects on these aquatic and aquatic-dependent ecological receptors in the Study Area. The BERA is summarized in Section 9 of the report and is found at Appendix G.

Approach to the Baseline Ecological Risk Assessment

Ecological receptors were chosen for the assessment based on criteria consistent with EPA Superfund guidance. The following complete and significant exposure pathways were quantitatively evaluated in the BERA using multiple lines of evidence:

- **Benthic invertebrates**—Direct contact with sediment and surface water, ingestion of biota and sediment, and direct contact with shallow TZW
- **Fish**—Direct contact with surface water, direct contact with sediment (for benthic fish receptors), ingestion of biota, incidental ingestion of sediment, and direct contact with shallow TZW (for benthic fish receptors)
- **Birds and mammals**—Ingestion of biota and incidental ingestion of sediment

[3] Additional data not evaluated as part of the RI and baseline risk assessments (see previous footnote) will also be considered as part of the FS.

- **Amphibians and aquatic plants**—Direct contact with surface water and shallow TZW.

The assessment endpoints for all ecological receptors are based on the protection and maintenance of their populations and the communities in which they live, with the exception of special status species (species that are protected by federal and/or state regulations or otherwise deemed culturally significant), which are assessed at the organism-level for survival, growth, and reproduction. In Portland Harbor, juvenile Chinook salmon, Pacific lamprey ammocoetes, and bald eagle were identified as special status species. For practical reasons and to be conservative, the organism-level measurement endpoints (survival, growth, and reproduction) were used for all receptors, requiring extrapolation to assess risks to populations and communities.

Results of the Baseline Ecological Risk Assessment

The following presents the primary conclusions of the BERA[4]:

- In total, 93 contaminants (as individual contaminants, sums, or totals) pose potentially unacceptable ecological risk. The list can be condensed if individual PCB, DDx, and PAH compounds or groups are condensed into three comprehensive groups: total PCBs, total DDx, and total PAHs. Doing so reduces the number of contaminants posing potentially unacceptable risks to 66.
- Risks to benthic invertebrates are clustered in 17 benthic areas of concern.
- Sediment and TZW samples with the highest hazard quotients for many contaminants also tend to be clustered in areas with the greatest benthic invertebrate toxicity.
- PAH and DDx compounds are the contaminants of potential concern in sediment that are most commonly spatially associated with locations of potentially unacceptable risk to the benthic community or populations.
- The most ecologically significant contaminants are PCBs, PAHs, dioxins and furans (as toxic equivalent [TEQ]), and DDT and its metabolites. PAHs and DDx risks are largely limited to benthic invertebrates and other sediment-associated receptors. PCBs tend to pose their largest ecological risks to mammals and birds.
- The combined toxicity of dioxins/furans and dioxin-like PCBs, expressed as total TEQ, poses the potential risk of reduced reproductive success in mink, river otter, spotted sandpiper, bald eagle, and osprey.

[4] The BERA findings described in the RI report are based on the RI data set, which includes data compiled through July 2010 and evaluated in the BERA. Additional sediment and tissue data have been incorporated into the FS data set and may be used to revise ecological risk estimates to inform the evaluation of remedy effectiveness.

REMEDIAL INVESTIGATION KEY FINDINGS

Section 10 of the RI report presents a CSM for the Portland Harbor Superfund site. The CSM synthesizes the extent of contamination, risks, sources, and the transport and fate of the contamination. Key findings of the RI CSM include the following:

Extent of Contamination

- Higher concentrations of contaminants in sediments occur in nearshore and off-channel areas.
- Contaminant concentrations in sediment are generally higher in deeper sediments than in the surface layer, indicating that past contaminant inputs were greater than current inputs, and that surface sediment quality has improved over time. The few exceptions include areas where higher surface sediment concentrations appear to be associated with ongoing sources, low rates of clean sediment deposition, or physical disturbance of surface sediments exposing contaminated subsurface sediment (e.g., from boat scour). In general, contaminant concentrations in surface sediments within the navigation channel and areas far from sources have relatively low concentrations that are similar to levels measured in sediments upriver of the Study Area in areas unaffected by industrial sources.

Estimates of Risk[5]

- PCBs, and to a lesser extent PCDD/Fs, PAHs, and DDx, account for almost all of the estimated human health risk. PCBs are the primary contributors to human health risk on a Study Area-wide basis, with ingestion of resident fish (e.g., bass, carp) representing the primary exposure pathway and the highest estimated risk. Consumption of fish and shellfish from the Study Area may pose health risks to humans that are greater than the EPA target risk range for human health (greater than one in a million [10^{-6}] to one in ten thousand [10^{-4}] excess risk of cancer). Other scenarios included in the assessment with health risks that may exceed EPA thresholds in parts of the Study Area were direct exposure to in-water sediment and future use of untreated river water as a hypothetical drinking water source.
- Total PCBs are the primary risk contributor to mink, river otter, and spotted sandpiper, and pose low risk to osprey, bald eagle, sculpin, and smallmouth bass. Total TEQ, which incorporates both PCB and dioxin and furan exposure, was also found to be a primary risk contributor to mink and river otter, and to pose low risk to spotted sandpiper, osprey, and bald eagle. Total DDx was found to pose low to negligible risk to bald eagle. Zinc, benzo(a)anthracene, benzo(a)pyrene,

[5] The identification of the contaminants that are the primary contributors to risk in various areas of the site consistent with EPA risk assessment guidance is not intended to suggest that other contaminants in those areas and at the site generally do not also present potentially unacceptable risk.

naphthalene, and DDx were found to pose localized risk to individual Pacific lamprey ammocoetes due to potential exposure to contaminated shallow TZW.

- Exposure to the mixture of contaminants present in the Study Area sediments is projected to pose unacceptable benthic risks for about 7 percent of the Study Area.
- Risk assessment methods were used conservatively to be protective of humans, fish, and wildlife and to minimize the chance of underestimating exposure and risk. As a result, the cumulative effects of the health protective assumptions and methods result in risk estimates that may be higher than actual risks within the Study Area.
- PCBs are a highly persistent compound found in fish on a regional (i.e., watershed-wide) and global level. Fish caught in the Willamette and Columbia rivers, outside of the Study Area, also contain PCBs that pose potentially unacceptable risk. Concentrations of PCBs in fish caught within the Study Area are higher than in regional fish tissue.

Sources of Contamination

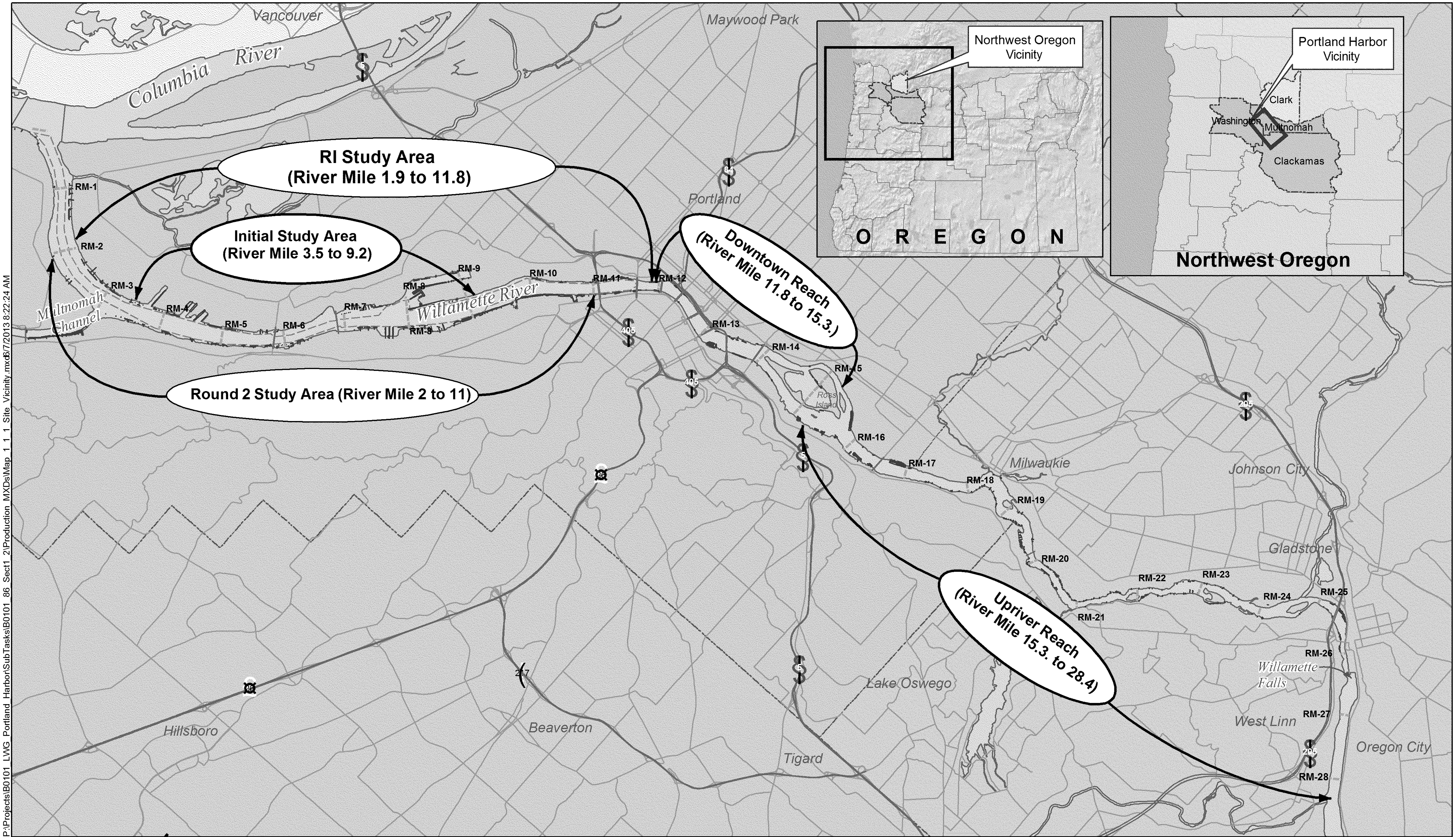
- Most of the sediment contamination in the Study Area is associated with known or suspected historical sources and practices that have largely been discontinued or otherwise controlled.
- Upstream sources to the Study Area include or have included sewers, stormwater runoff, direct discharge of industrial wastes, agricultural runoff, and aerial deposition of global or regional contaminants on the river water surface and drainage areas within the Willamette Valley.
- Contaminants still reach the Study Area through various pathways, including stormwater, permitted industrial discharges, atmospheric deposition, bank erosion, groundwater, and incidental releases within the Study Area, and in surface water and sediment inflows from upstream.
    - The mass of most contaminants currently entering the Study Area from upstream river flows (in surface water and suspended sediments) per year exceeds the current mass from upland sources within the Study Area. This is due to the large volume of water and sediments that enters the Study Area from upstream.
    - Stormwater input is likely the most important current source pathway within the Study Area (i.e., excluding upstream sources) for many contaminants.
    - Contributions of groundwater contaminants to the Study Area have been identified at several upland properties with known groundwater contaminant plumes that are migrating to the river.
- The main ongoing contaminant inputs quantified in the RI report are upstream surface water inputs (all upstream watershed sources), local stormwater in the Study Area, groundwater, and atmospheric deposition. Some unquantified sources such as bank erosion may also be important in localized areas.

- Although many specific sources of contamination have been identified, the RI report is not an exhaustive list of current or historical sources of contamination. Identification and evaluation of potential sources is ongoing.

Contaminant Transport and Fate

- Most of the sediments with the highest contaminant concentrations that pose potential risk are located in relatively stable, nearshore areas.
- Most nearshore areas and much of the navigation channel are stable, depositional environments, although localized areas may be subject to anthropogenic disturbances. Two well-defined portions of the channel (i.e., RM 5 to 7 and upstream of RM 10) are more dynamic and potentially subject to erosion during flood events. Deep sediments (greater than 1-ft sediment depth) in these two channel areas are not highly contaminated. Extreme high-flow events have the potential to re-expose the buried contaminants in these areas, posing potential future risk in and possibly downstream of these areas.
- Sediments immediately downstream (and upstream) of the Study Area in the Willamette River main stem or in Multnomah Channel show relatively little contamination, which is evidence of limited contaminant migration from the Study Area. Contaminants associated with sediments in any large river system have the potential to be transported downstream (and even upstream during flow reversals) over time, but the elevated sediment contaminant levels within the Study Area appear to have largely remained proximal to known or likely sources.

The results of the Portland Harbor RI, including the human and health and ecological risk assessments, provide the information necessary to evaluate remedial alternatives to reduce risk to human health and the environment. This evaluation will occur during the FS.



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integral consulting inc.

FEATURE SOURCES:
Transportation,Property, or Boundaries: Metro RLIS.
Channel & River Miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

0 1 2 3 Miles

Map Features

- River Miles
- Bridges
- Major Hwy & Frwy
- Docks and Overwater Structures
- Navigation Channel

County

- Clackamas
- Clark
- Multnomah
- Washington

LWG LOWER WILLAMETTE GROUP

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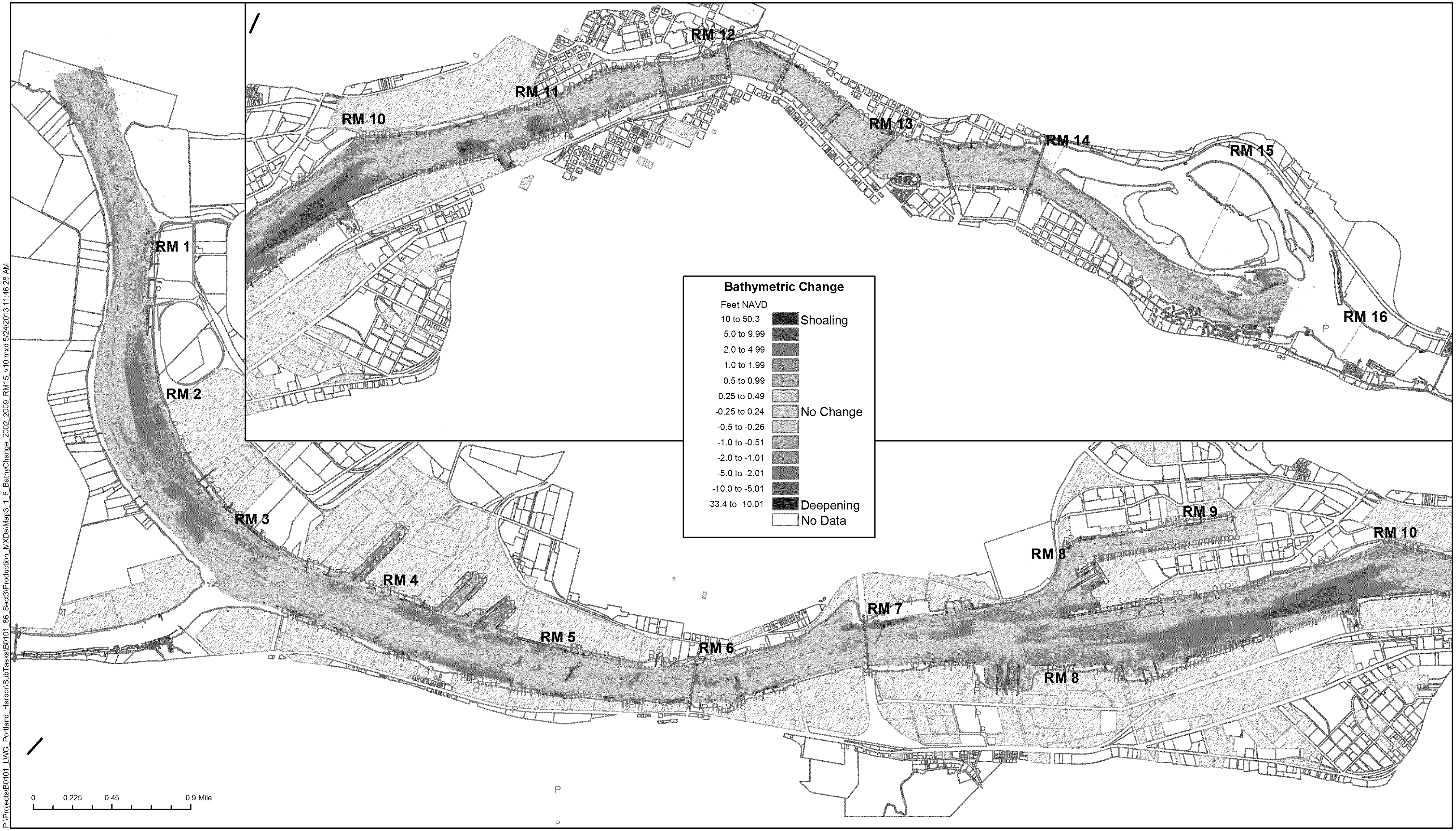
Figure ES-1
Portland Harbor RI/FS
Remedial Investigation Report
Portland Harbor Study Area and Vicinity



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LWG LOWER WILLAMETTE GROUP

FEATURE SOURCES:
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Map Features

- River Miles
- Bridges
- Docks and Structures
- Navigation Channel

Outfalls

- Outfall
- Dock Drain
- Roof Drain

- Upland ECSI Sites (2008)
- Waterfront Taxlots
- River Edge +13 ft NAVD

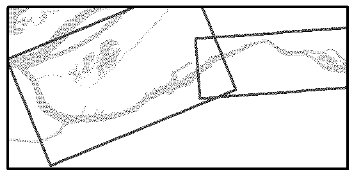

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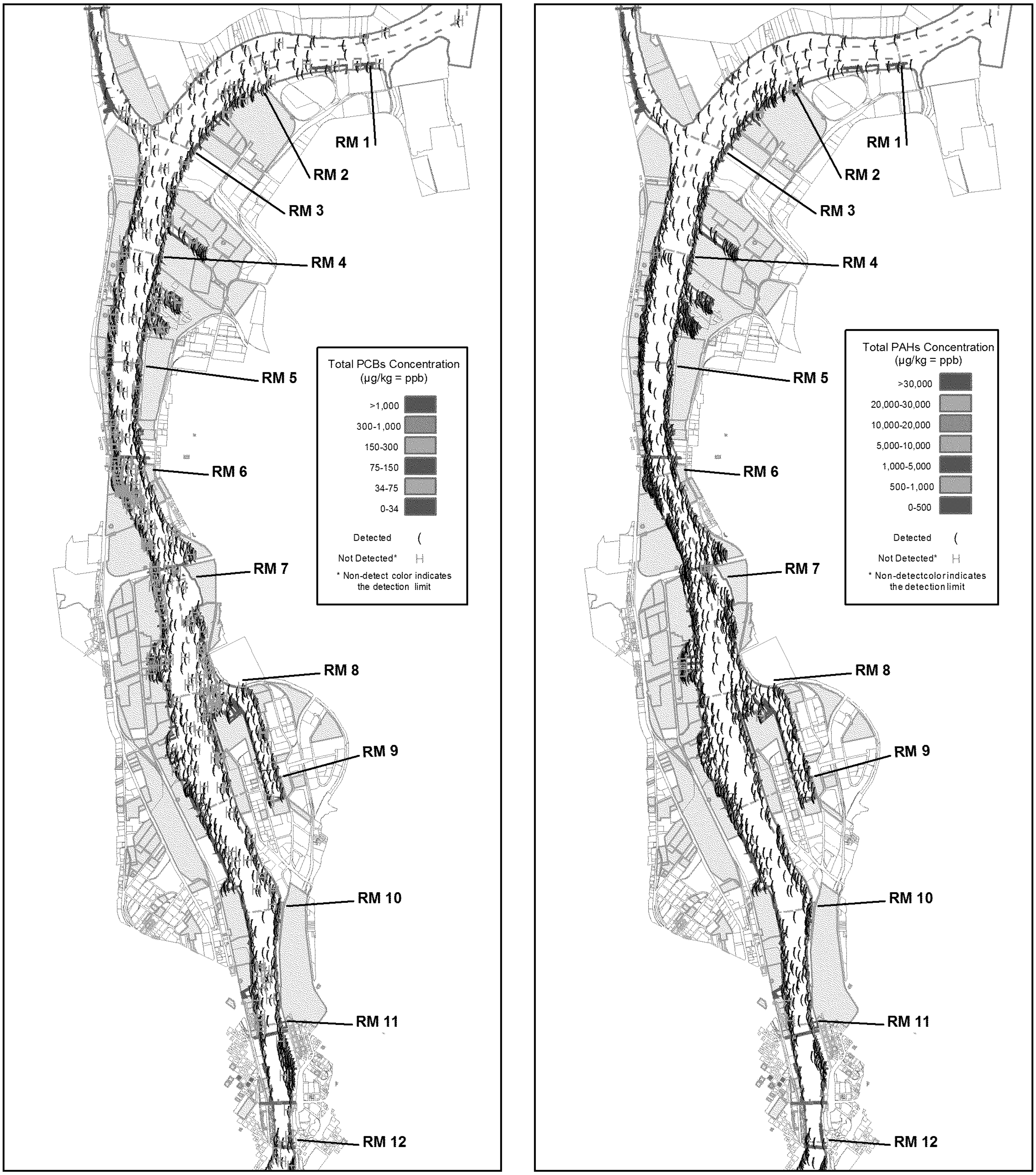
Figure ES-2
Portland Harbor RI/FS
Remedial Investigation Report
Bathymetric Change
January 2002 to January 2009



0 0.25 0.5 1
Miles

FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

Map Features

River Miles
Navigation Channel
River Edge +13 ft NAVD
Bridges
Waterfront Taxlots
Upland ECSI Sites (2009)
ECSI: Oregon Environmental Cleanup Site Inventory

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ES-3
Portland Harbor RI/FS
Remedial Investigation Report
Surface Sediment Samples (0 - 30cm)
Total PCBs and Total PAHs Concentration

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